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Spreadsheet Generation of a Truth Table

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Spreadsheet Generation of a Truth Table

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Abstract

Truth tables are an introductory method of evaluating a logical expression or proving an argument. They are, however, cumbersome to construct and apply by hand. This report shows that a spreadsheet can generate truth tables rather easily. A simple example is given of a spreadsheet computing the truth value of an expression of logical variables.

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1. Introduction

The deductive reasoning of arguments can be proven (i.e., Do the premises lead to the conclusion?) by analysis methods of symbolic logic. The introductory method of proving the validity of arguments uses truth tables. The drawback to the truth table method of proof is that it is cumbersome--a schema for making tables may not be known to the user, and there are too many table entries.[1] Moreover, the truth table method of proof is soon abandoned because better methods are available.[2] The basic method might be revived with a spreadsheet because the speed and thoroughness of the computer overcomes the tediousness of making and applying truth tables. This report shows that a spreadsheet can easily generate truth tables by an iterative method of building each table from the previous one. Truth tables for n variables can be generated ahead of time, stored, and retrieved for later use. A smaller application of a truth table (e.g., supplying values to a 2-variable logical expression) will be shown, but proof of arguments is outside the scope of this brief report.

2. Truth Table Generation

A logical variable takes on the values of *true* (T) or *false* (F). For one variable *p*, the truth table is:

1-Variable Truth Table
p
T F

[1]A logical variable can take just two values, *true* or *false*, but all combinations of values of *n* variables must be tested, which requires a table of 2^n rows by n columns. For instance, five variables create 160 table entries ($2^5 \times 5 = 160$), which are lengthy to write out and apply.

[2]The usual method of establishing an argument's validity is recasting the premises using the *rules of inference* to list permissible statements that lead to the conclusion. (The logician's art and skill are important for fashioning a short proof.)

A truth table with several variables is just a list of all the combinations of T and F that can exist. The combinations are written in the "standard order" peculiar to a profession. For the two logical variables *p* and *q*, the standard-order truth table is:

2-Variable Truth Table	
p	q
T	T
T	F
F	T
F	F

For the three variables *p*, *q*, and *r*, the truth table is:

3-Variable Truth Table		
p	q	r
T	T	T
T	T	F
T	F	T
T	F	F
F	T	T
F	T	F
F	F	T
F	F	F

The 2- and 3-variable truth tables show that there is a repeating pattern. The pattern is that the shaded portion of the 2-variable table is repeated twice in the 3-variable table, once for *p* true and once for *p* false. Another way of describing the pattern is that there are $2^3 = 8$ rows of values for the 3-variable table. In the first column headed *p*, the first half of the rows is *true* and the next half *false*. The 2-variable table values are supplied against the *trues* and *falses*, completing the table.

The pattern and the 3-variable table comprise the next table. The 4-variable table has 16 rows (2^4) of values, and the first column headed *p* will get the first half of the rows *true* and the next half *false*. The 3-variable table values (unshaded portion) are supplied against the *trues* (herringbone up) and also against the *falses* (herringbone down), which completes the table.

4-Variable Truth Table			
p	q	r	s
T	T	T	T
T	T	T	F
T	T	F	T
T	T	F	F
T	F	T	T
T	F	T	F
T	F	F	T
T	F	F	F
F	T	T	T
F	T	T	F
F	T	F	T
F	T	F	F
F	F	T	T
F	F	T	F
F	F	F	T
F	F	F	F

The tables are rapidly made in a spreadsheet or word processor because both programs carry the *copy* and *paste* commands that allow highlighting the section that is carried forward to the next table. The leftmost column will always be *trues* for the upper half of rows and *falses* for the bottom half of rows. Thus, generating truth tables is advanced one at a time. Each table can be highlighted and saved as a file, so that it does not have to be regenerated in sequence each time it is needed.

3. Spreadsheet Particulars

Knowing about the organization of spreadsheets helps users save and retrieve work. Spreadsheet programs are designed as notebooks of many tabbed pages (i.e., sheets). It is the whole notebook that is given a path name ending in a file name. To retrieve a particular page, the user selects the notebook name from the file menu and opens the sheet of truth tables by clicking the mouse arrow on the tab. All of the truth tables that can fit on a sheet are saved and viewed together. However, since the hodgepodge of tables on the sheet is unworkable, a feature called a *block name* is used to retrieve a particular one.

The steps followed in the Corel Quattro Pro 8 spreadsheet program are: 1) highlight a finished truth table, 2) click on the menu names "Insert|Name|Cells," 3) type an obvious name for the block, 4) click Add, and 5) click Close. For instance, the 2-variable truth table would be called "2var," and so on. If the names of the blocks are forgotten, they can be reviewed in the above menus. To put the suggested block on a new sheet, the user types "+2var" and the entire block of data is printed on the screen. (The block can be quickly deleted by just deleting the named cell [left top corner].)

The ultimate point of having a truth table is to evaluate arguments by the truth table method. The tabled combinations listed so far contain no logical values for computing; they are made with a word processor and are just for looks. Even if they are first made in a spreadsheet, extra measures are needed to change the cells T and F into true and false logical values.

The purpose of the new block, which could be called a logic table, is to supply values for a logic expression that is typed in the next column(s). The new block, started alongside the truth table, is made from a *conditional if* function. If the block named 2var started in cell A1, then @IF(A1="T", @TRUE, @FALSE) would be typed at C1 and entered. Next, highlighting a 4 x 2 block (left top corner at cell C1 and right bottom corner at cell D4) and clicking the *speedfill* icon opens the "Cell Reference Checker" box, and clicking Close fills the block with *1*s and *0*s corresponding to T and F in the 2var block. Only the 1s and 0s are recognized by the spreadsheet as having the logical values true and false. The new block should be saved under a block name such as "2logic." On a new sheet, "+2logic" is typed into any cell, the table appears, and next to the table is entered the logical expression to be evaluated is entered.

A faster way to make the logic tables is to omit the n-var blocks and work only with the n-logic blocks. For instance, to create 3logic, skip over one cell from where that table is to start and type and enter "+2logic" to retrieve the 2-variable logic table. Return to the skipped cell (it will become the head of the leftmost column of 3logic) and type and enter @TRUE. Highlight down to the last row of 2logic and click on speedfill to fill the blank cells with logical trues ("1"). At the cell where the block should be repeated, "+2logic" is again typed and entered. The leftmost column of 3logic is completed by typing and entering @FALSE, highlighting down, and speedfilling to give the blank cells logical falses ("0"). With that, the logic table is complete and the block should be given its recognizable name.

4. Application

4.1 A Very Simple Example. A *logical expression* is any combination of the logical operators *and, or,* or *not* acting on logical variables. The *truth value* of the expression depends on the values that are tried from the truth table. For example, the truth value of the logical expression *p and q* (abbreviated p·q) is true only if p and q are individually true. The 2logic table reveals all possible values of the expression p·q. As the table confirms, if either p or q is false, the conjunction is false.

	A	B	C
	p	q	p·q
1	1	1	1
2	1	0	0
3	0	1	0
4	0	0	0

Since the table entries start at cell A1 (p true) and B1 (q true), the spreadsheet entry in C1 (p·q) is written +A1#AND#B1. The empty cells below that entry are highlighted, and the speedfill icon is clicked. The spreadsheet then computes the values (ones and zeros) shown. This very simple example illustrates the truth table method of evaluating a logical expression.

4.2 A Simple Example. Some easy, successful examples of computing the logical value of expressions with a spreadsheet are shown for five examples involving two variables. The various connectives of the variables p and q are: p·q means p and q, v means or, and ~ means not. The logic table that the spreadsheet uses is in columns A and B; five different expressions are in columns C - G. The computed results are easily mentally checked by the ordinary understanding of the logical results of combinations of true and false statements.

	A	B	C	D	E	F	G
	p	q	p·q	p v q	p·q v p	~p	p·q v ~p
1	1	1	1	1	1	0	1
2	1	0	0	1	1	0	0
3	0	1	0	1	0	1	1
4	0	0	0	0	0	1	1
	2-logic table		five logical expressions evaluated				

Although these 2-variable examples are simple, the spreadsheet can compute much more complicated expressions of numerous variables.

5. Conclusion

Because truth tables contain a pattern, it is easy to generate the next higher table from an existing one. By using a spreadsheet, large truth tables can be generated, saved, and applied to large expressions that are impractical to evaluate by hand.

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